

ESTIMATION OF ERRORS IN THE TOMS TOTAL OZONE MEASUREMENT DURING  
THE ANTARCTICA OZONE CAMPAIGN OF AUGUST/SEPTEMBER 1987

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The TOMS instrument on the Nimbus-7 satellite provides the primary source of total ozone data for the study of total ozone in the polar regions of the earth. There are no comparable instruments either on the ground or on the satellites that provide the coverage, the accuracy and the spatial resolution of TOMS necessary for understanding the dynamical and chemical processes that may have triggered the formation of the ozone hole in the Antarctica region.

However, by the time of the Antarctica Ozone campaign of Aug/Sept 1987, TOMS had completed almost nine years of continuous operation in space during which there has been degradation in the instrument's performance resulting in significant calibration drifts and increased noise. In addition, the unusual atmospheric conditions prevailing in the Antarctica ozone hole, such as very low stratospheric temperatures, stratospheric clouds, and extremely low ozone amounts were not anticipated in the design of the TOMS retrieval algorithm. The purpose of this paper is to quantify the errors in the TOMS total ozone measurements resulting from both the instrument degradation and the retrieval algorithm.

There are two types of instrument related errors: a slowly developing drift in the instrument calibration since the launch of the instrument in October 1978 and an increase in the measurement noise beginning April, 1984. We estimate that by October 1987, the accumulated error in the TOMS total ozone measurement due to instrument drift is about 6 m-atm-cm. The sign of the error is such that the TOMS is slightly overpredicting the long-term decrease of the Antarctica ozone. The increase in the measurement noise is more difficult to quantify affecting some measurements by as much as 10 D.U. and others not at all. A

detailed analysis of this error and its potential impact on the studies of total ozone from TOMS will be provided.

There are three categories of algorithmic errors: 1) error due the unusual shape of the ozone profile in the ozone hole 2) error caused by very low atmospheric temperatures in the ozone hole affecting the ozone absorption cross-sections at the TOMS wavelengths, and 3) errors resulting from occasionally thick stratospheric clouds that sometimes reach to 20km in the ozone hole .

Simulation results indicate that the TOMS ozone retrieval technique is quite robust; even for the highly unusual ozone and temperature profiles found in the ozone hole the algorithm returns total ozone values close to the correct answer. Very close to the terminator the current TOMS algorithm may underestimate the total ozone by as much as 10 m-atm-cm but the error decreases rapidly with decreasing solar zenith angle. We will propose some simple algorithmic modifications, such as giving more weight to the longer (more penetrating) wavelength pairs, that can reduce this error even further.

Errors in the presence of clouds are harder to quantify since little information is available about the total optical thickness and vertical distribution of these clouds. Though the satellite measurements such as SAGE II and SAM II and the measurements from the aircraft detect significant amounts of stratospheric aerosols/ice clouds before and during the ozone hole episode, these clouds are generally too thin to produce significant error in the TOMS total ozone determination. Normal tropospheric clouds found in the south polar regions also produce little or no errors in the TOMS measurements. There are, however, aircraft reports of very high altitude (10-15 km) cirrus type clouds that may have large enough optical thickness to produce significant error in the determination of the TOMS total ozone.

Lacking the necessary information about the optical properties of the stratospheric clouds, we will provide results of sensitivity calculations for clouds of various optical thicknesses at different heights in the atmosphere. Further studies- a careful analysis of visible and infrared pictures from the AVHRR instrument on the NOAA satellites coupled with the aircraft measurements and the ultraviolet reflectivity data from TOMS - will be necessary before one can provide reasonable upper and lower bounds on the errors due to stratospheric clouds.